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USSR:
Cost of the Space Program

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A Research Paper

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SOV 85-10069
April 1985

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USSR: Cost of the Space Program [redacted] 25X1

A Research Paper

This paper was prepared by [redacted] 25X1
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USSR:
Cost of the Space Program [redacted] 25X1

Summary

Information available as of 1 March 1985 was used in this report.

The Soviet space program in the 1980s is undergoing rapid growth comparable to that achieved soon after the program was initiated in the mid-1950s. As the program has matured, its orientation has shifted to emphasize military and future economic applications over lunar and planetary programs designed primarily to enhance national prestige. To assess the overall pace of these programs and their changing orientation, we use the common denominator of dollar costs—estimates of what it would cost the United States to duplicate the Soviet program. We estimate the annual dollar costs of the program (including research and development, procurement, operating, and support costs), expressed in 1983 prices, have risen from the equivalent of over $8 billion in 1965 to over $23 billion in 1984—averaging growth of about 6 percent per year. The average annual growth rate in the early 1980s has been a more dramatic 18 percent. [redacted] 25X1

We estimate that R&D has accounted for just over one-third of the cumulative space program costs and has driven the major trends:

- About two-thirds of the R&D costs are accounted for by space launch vehicles (SLVs). Failure of the SL-X-15 heavy-lift booster—the largest cost item—in the early 1970s resulted in a retrenchment in the entire space program. The new SL-W heavy-lift booster probably will be first launched in the mid-1980s and is one of the major drivers of the upturn in space program costs in the 1980s.

- Estimated spacecraft R&D costs have experienced less fluctuation. Unmanned spacecraft—mainly for intelligence collection and communications—accounted for a large share of early expenditures, but expensive programs to develop a manned space shuttle, a spaceplane, and large space stations have begun to dominate spacecraft R&D expenditures. [redacted] 25X1

Space system procurement and operating costs have grown more steadily than R&D costs. Growth through the early 1970s was accounted for mainly by increasing launch rates; since then, these costs have risen largely because of the introduction of new and considerably more expensive SLVs and spacecraft. Throughout the space program's history, however, Soviet emphasis on evolutionary space system design, component commonality, and proven technology have held down the rate of growth in both R&D and procurement costs. [redacted] 25X1

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Since the mid-1970s the Soviet space program has steadily become more oriented toward the military. We estimate the civilian share of the costs has declined from about two-thirds of the costs in the late 1960s to about one-third in 1984. [redacted] 25X1

We believe the growth in space program costs will be sustained through the late 1980s. Manned missions (including military applications) and intelligence collection missions will dominate, each accounting for about one-third of the estimated dollar costs for the next five years. Other military missions will account for much of the remaining costs. Failure of or delays in key development efforts would result in lower cost growth than we project, however, especially in procurement and operating costs. Significant delays in developing the SL-W booster would be particularly disruptive, especially to those missions dependent on it, such as the manned program. [redacted] 25X1

Statements by Soviet scientists indicate there may be a resurgence in civilian lunar, planetary, and astronomical programs by the late 1980s or early 1990s. This would occur after most of the major new military spacecraft had been deployed, thereby lessening the competition for funding. However, a Soviet response to the US Strategic Defense Initiative would probably retard and possibly eliminate this anticipated resurgence.
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Background

Since its origin in the 1950s the Soviet space program has been given a high priority and has grown more rapidly than most other military or scientific programs. Although the Soviets were the first to enter space, they have generally trailed the United States in achieving new space capabilities.[1] Nevertheless, the Soviets now have systems in operation or in development that will enable them to duplicate most of the basic missions in the US program, and they are developing manned spacecraft—such as the spaceplane and large space stations—that may afford them unique capabilities in the near future.[2] [redacted] 25X1

In the 1950s the Soviets established the research and development (R&D) and production infrastructure for the space program and initially concentrated on developing space launch vehicles (SLVs). In so doing, the industry borrowed many facilities and programs from the existing missile and aircraft industries.[3] All of the SLVs operational through the early 1970s, and six of the eight currently operational, were derived from IRBMs or ICBMs that flew prior to 1965. The first scientific and manned missions, flown in the late 1950s and early 1960s, provided a series of space firsts, including Sputnik, the first manned orbital flight, and the first space walk. The spacecraft flown on these missions probably were designed, at least in part, to enhance Soviet prestige; but they also were being considered for military applications—either as weapon platforms or as support systems. [redacted]

In the early 1960s the Soviets began to broaden the space program to include more practical economic and military applications, while continuing the prestigious lunar and planetary missions. [redacted] 25X1

[redacted] 25X1

[redacted] 25X1 Lunar and planetary missions and manned missions in low Earth orbit continued to be prominent but were constrained by the relatively low-lift capabilities of the first generation of SLVs. In the late 1960s the Soviets tested the larger and more complex SL-12/13 Proton and SL-X-15 systems, developed strictly for use as SLVs.[4] The SL-12/13 proved highly successful, but the SL-X-15 (comparable in size to the US Saturn V) failed and caused a number of development programs and missions to be aborted. [redacted] 25X1

After this setback Moscow redirected its space program in the early 1970s, emphasizing manned missions in low Earth orbit. The Soviets partly compensated for the lack of a heavy-lift booster by using smaller SLVs for frequent spacecraft launches and by assembling smaller modules to construct space stations. Since 1971 small space stations have been orbiting almost continuously, and each mission has been longer and more complex. [redacted] 25X1

[redacted] 25X1 25X1 25X1

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[2] The US space station will not be operational until at least the early 1990s, a few years after deployment of the Soviet station is expected. [redacted] 25X1

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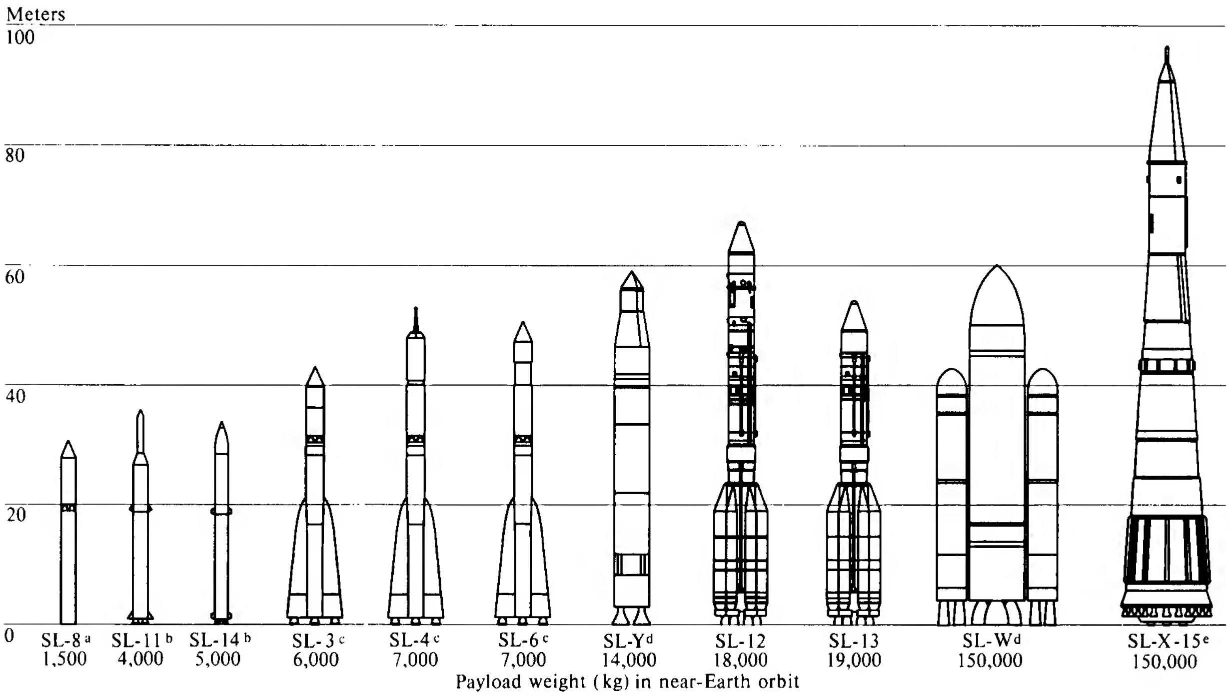
Figure 1
Soviet Space Launch Vehicles



a Derived from SS-5 IRBM. c Derived from SS-6 ICBM. e Canceled in mid-1970s.
b Derived from SS-9 ICBM. d Under development.

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such as the space shuttle and probably the space-based laser will use this new booster.[redacted] 25X1

[redacted] 25X1

The space program in the 1980s is undergoing rapid growth comparable to that achieved soon after the program was initiated in the mid-1950s. Our analysis of system developments and operations indicates this growth will continue throughout the decade:

[redacted]

slightly in the late 1980s or early 1990s when the space shuttle becomes operational. We estimate the number of spacecraft in orbit will grow to about 140 by 1990.

• [redacted] analysis of systems in development indicate that space-related design bureaus, production facilities, launch complexes, control sites, support ships, and cosmonaut training facilities will grow at rates equal to or exceeding their average growth rates since the 1950s.[redacted] 25X1

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Figures 1 and 2 and table 1 provide an overview of Soviet space system developments and operations.[6] We have identified a total of 17 SLVs and 38 major

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types of spacecraft, including those still in development [redacted] Although the number of launches has been roughly stable since the early 1970s, the launches have supported an array of increasingly more capable, longer lived spacecraft. The Soviets launch more satellites annually than the United States, but maintain about the same number in operation because of shorter lifetimes (see figure 2). [redacted]

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Space Program Cost

We estimate the cost of Soviet space activities by calculating what it would have cost the United States (in dollars) to develop, launch, and operate identified

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Figure 2
Successful Launches Per Year, United States Versus USSR, 1957-84

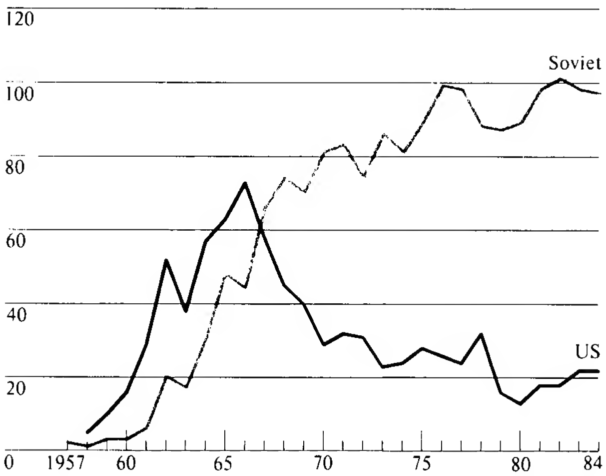

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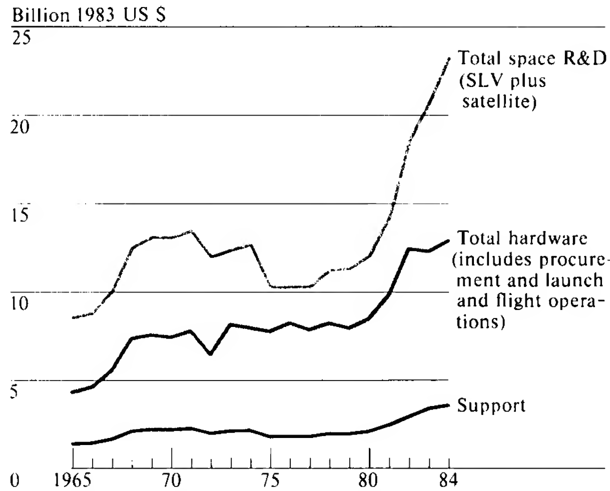
Figure 3
Total Dollar Costs of Identified Soviet Space Activities, 1965-84



Dollar estimates represent what it would cost to replicate Soviet development and procurement in the United States and then launch and operate systems as the Soviets would. These costs represent only those programs—existing or planned—for which we have evidence. They may, therefore, underestimate total program costs in general and R&D in particular.

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systems as the Soviets have done. [redacted] 25X1

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Dollar costs convey an impression of the pace and magnitude of the Soviet program and permit comparisons between elements of the space program as well as, in the aggregate, between the Soviet and US programs. Estimates in rubles are needed to portray actual Soviet spending and to measure the impact of space programs on the economy or Soviet perceptions of their usefulness. Our estimates probably underestimate total costs because we figure costs only for what we observe. We do not believe this is a significant problem, however, because we are confident we do not miss any large programs. [redacted]

Using this approach, we estimate that annual Soviet space program costs—including R&D, procurement, operations, and support costs—have risen from over $8 billion in 1965 to over $23 billion in 1984 (expressed in 1983 dollar prices). This represents an average annual growth rate of about 6 percent (see figure 3). The average annual growth rate in the early 1980s, however, has been almost 18 percent. R&D has accounted for about 35 percent of the cumulative estimated costs, a high share that demonstrates the technical challenges of operating in space [redacted] 25X1

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The dollar costs of the space program have fluctuated considerably over the period, mainly in response to the fate of major Soviet R&D initiatives. Those components of total costs that we can readily measure—procurement, operations, and support—have demonstrated steady growth.[7] R&D costs have fluctuated

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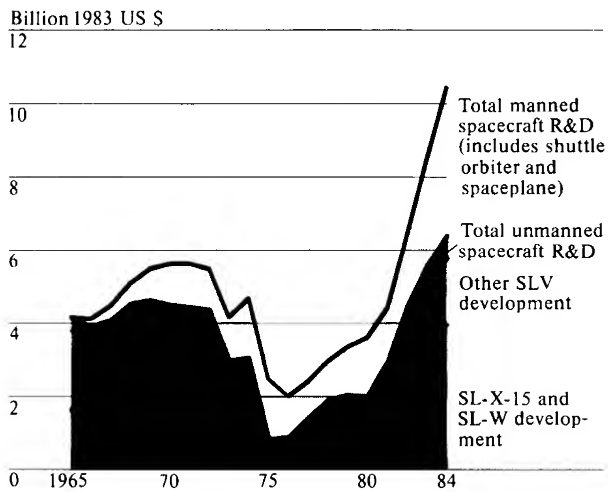
Figure 4
Dollar Costs of Soviet Spacecraft and Launch Vehicle Development, 1965-84



Dollar estimates represent what it would cost to replicate Soviet development in the United States, using US technology levels. These costs represent only those programs–existing or planned–for which we have evidence. They may, therefore, underestimate overall R&D costs, particularly in the late 1980s. [redacted]

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widely because of two significant efforts. Retrenchment in the early 1970s followed the cancellation of the SL-X-15 and its associated heavy spacecraft, and expansion in the late 1970s and early 1980s resulted from a broad commitment to expensive manned space programs (see figure 4). However, inclusion of only R&D costs that we can directly associate with a hardware development program tends to accentuate fluctuations, insofar as we fail to account fully for the general planning, research, and overhead expenditures between major programs. [redacted]

Research and Development

Space Launch Vehicles. Between 1965 and 1984 SLV development accounted for about two-thirds of the estimated space system development costs. We estimate the dollar costs (1983 prices) of SLV development through 1984 were about $85 billion, including $60 billion for programs since 1965. Most of the pre-1965 programs—including the SL-3, SL-4, SL-6, SL-7, SL-8, and SL-14—required fewer resources than later ones because they used converted ICBM or IRBM boosters for launchers. We estimate the first booster built exclusively for the space program—the four-stage SL-12 and its three-stage version, the SL-13—cost more to develop than all previous SLVs combined. [redacted] 25X1

The first attempt to develop a heavy-lift SLV similar to the US Saturn V accounts for the largest expenditure in our estimate of Soviet space program costs. Development of the SL-X-15, which commenced in the early 1960s, was prompted by Soviet interest in lunar landings and other manned interplanetary missions. During the first launch attempt in July 1969, the booster exploded a few seconds after first-stage ignition, damaging the launchpad and, according to several emigres, killing many people. Following two more unsuccessful attempts, a redesign effort was initiated which probably involved extensive modifications to the propulsion system. [redacted] first three 25X1 stages of an SL-X-15 at the launch complex during early 1974, but no launch was attempted and subsequently the program was canceled. This program failure was probably a major reason for the shift in emphasis from lunar landings to manned space stations. [redacted] 25X1

The Soviets designed the SL-X-15 using only proven technology. The first stage had as many as 30 conventional engines rather than more advanced liquid hydrogen engines such as those used in the United States. Consequently, the SL-X-15 was more complex, but less technologically advanced, than the Saturn V. Its very large structure required the development of new fabrication, welding, and handling techniques; its larger combustion chambers created problems in combustion stability; and its many engines required a highly complex propellant feed system. These requirements increased the SL-X-15's development costs significantly. [redacted] 25X1 25X1 25X1

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Spacecraft. The Soviets develop more unmanned than manned spacecraft, but unmanned spacecraft account for a relatively small share of space system R&D costs. Manned versions are considerably more expensive to develop because of their larger size, greater complexity, and requirements for additional equipment to provide crew habitability and safety. [redacted] 25X1

We estimate the annual dollar costs for the development of unmanned spacecraft have fluctuated between \$250 million and \$750 million, depending on the number of programs conducted simultaneously, and we expect this level of activity to rise only slightly in the late 1980s. [redacted] 25X1

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Unmanned spacecraft now in development generally incorporate major advances in satellite payloads or sensors. The Soviets continue to emphasize evolutionary improvements in propulsion, structure, and power supply, which reduce overall development costs. [redacted] 25X1

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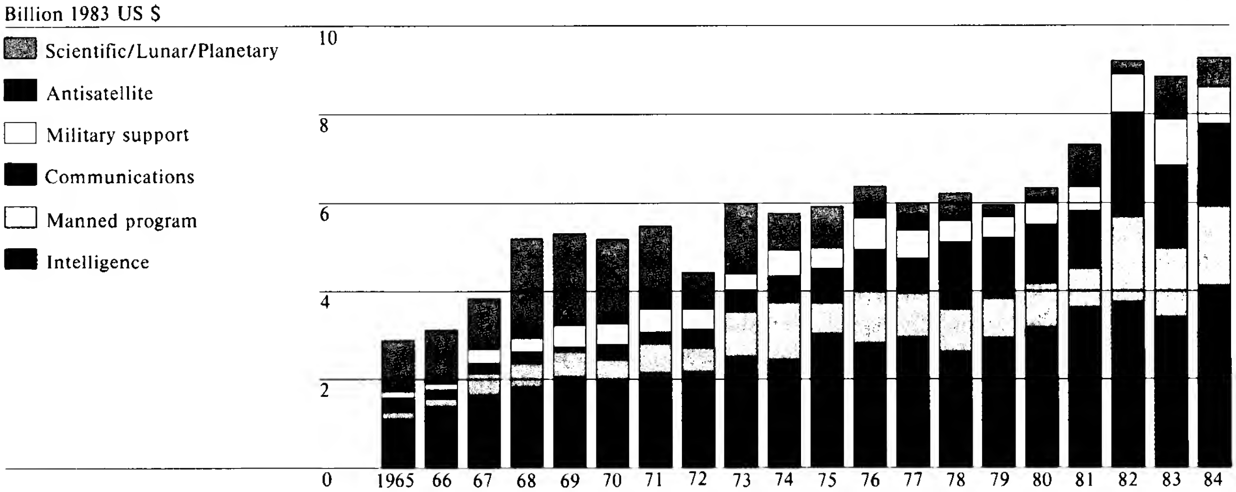
[redacted] A network of data relay satellites will provide intersatellite linking. New communications satellites—the Gals, Luch, and Volna networks—will use a common platform, and the resulting hybrid satellite programs will share its development costs. [redacted] 25X1

[redacted] 25X1

Figure 5
Soviet Space Program Procurement and Operating Costs by Mission Category, 1965-84



The costs of procuring the spacecraft and associated launch vehicles, as well as the costs of launching and supporting a system, are included here.

[redacted]

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[redacted] We estimate the cumulative dollar costs since 1965 of developing this relatively simple and slowly upgraded system have been about $500 million. [redacted]

The manned program, a major factor in space programs since the first Vostok launch in 1961, is now beginning to dominate Soviet space efforts. The Vostok series, used for low-altitude checkout of life support systems, was followed by Voskhod tests of multiman spacecraft and rendezvous procedures. The next new design—the Soyuz—was the basis for the Soyuz-T, the Progress cargo resupply vehicle, and the military and civilian Salyut space stations. In 1977 the Soviets tested a new smaller station or multipurpose vehicle, Cosmos 929. This vehicle has a unique two-section configuration with a recoverable front end. Soviet statements suggest versions of this spacecraft will be used as part of a modular space station and possibly to recover materials from the space station complex. Throughout the manned program, evolutionary design approaches have significantly reduced development costs (see appendix). [redacted]

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Procurement and Operations
The estimated dollar costs of procurement and flight operations have risen since 1965 at an average of about 7 percent per year; since 1980 they have increased about 10 percent per year. This growth is attributable mainly to increases in the estimated costs of procuring newer SLVs and spacecraft (see figure 5). [redacted]

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Recent growth in the SLV component of procurement and operating costs has resulted from increased use of the SL-12/13. The manufacturing facilities for this vehicle were expanded in the late 1970s to more than double their previous production capacity. In 1984 the Soviets set a new record of 14 launches of the Proton. We believe launch vehicle costs will continue to rise substantially in the mid-to-late 1980s as the two new launch vehicles, the SL-Y and the SL-W, enter the inventory. [redacted]

Increased use of the SL-12/13 has coincided with increases in procurement of sophisticated manned and communications spacecraft. The manned space program has expanded especially rapidly, because the Soviets have systematically increased the duration and complexity of their space station operations. Procurement costs have grown with the move to modular Salyut/Cosmos 929–type stations, while operating costs have increased with the frequent use of crew and cargo resupply vehicles. We believe the manned program will account for about 25 percent of procurement and operating costs by the late 1980s. [redacted]

[redacted]

The number of Soviet space launches has remained generally steady since the late 1960s at about 100 per year—a high rate necessary to maintain the networks of single-mission, short-lived satellites and to account for Soviet geography. In 1982, for example, the Soviets had to launch a record 107 satellites in order to maintain approximately 110 operational payloads in orbit. The US Intelligence Community has estimated that improvements in Soviet spacecraft reliability in the 1980s should afford average lifetimes of three years—better than the one-year average in the 1970s, but still considerably less than the US average of seven to 10 years. Geography forces the Soviets to use numerous communications satellites to ensure reliable communications in the higher northern latitudes; they must deploy multiple satellites in highly elliptical, semisynchronous orbits rather than a single spacecraft in geosynchronous orbit. [redacted] 25X1

Support Systems

Operational support for the wide variety of Soviet spacecraft is provided by an integrated network of land- and sea-based tracking stations. Unlike the worldwide, land-based space tracking network of the United States, Soviet support ground stations are located only in the USSR. To supplement this network, the Soviets deploy approximately a dozen ships with specialized equipment to achieve global coverage, primarily to support manned missions. Dedicated communications satellites and landlines link these stations and ships with a central coordinating computer center and with special mission-oriented flight control centers. Certain high-priority programs, such as the manned program, enjoy the exclusive use of dedicated ground station equipment. [redacted] 25X1 25X1 25X1

[redacted] the Soviets are upgrading nearly all of their ground stations to support more sophisticated missions in the future. In addition, a new satellite network is expected in the mid-to-late 1980s to relay digital data between individual ground stations. We believe three very large support ships—including a nuclear-powered one—may be under construction to augment the existing fleet of three space operations control ships (SSOCS) and eight space event support ships (SSESS). The SSOCS can perform most of the major functions of a control center, while the SSESS are used primarily to collect telemetry during critical mission phases. During the 1980s we estimate the annual dollar cost of operating this network of tracking facilities and ships will average $1.2 billion. The remaining support costs include the costs of constructing new launch, tracking, and support facilities and the costs of the general support and administrative activities necessary to maintain the space program. [redacted] 25X1 25X1 25X1

Military Versus Civilian Costs

Arraying costs by military and civilian programs is inexact because it requires a number of assumptions about the allocation of effort.

However, approximately 15 percent of the spacecraft launched—including those in the very expensive manned program—are used for both civilian and military applications. All of the space station missions have included military experiments, and some have been almost exclusively military. Most Soviet communications, meteorological, and navigation satellites support civilian and military customers, and the earth resources satellites, although primarily designed to provide economic data, may perform at least minimal intelligence-collection functions as well. Even purely scientific programs may support future military applications. Soviet statements indicate that a 1983 Venus probe carried a synthetic aperture radar, which probably was provided by a military designer and may be incorporated in future intelligence-collection spacecraft for an all-weather, day and night imaging capability. For such dual-use programs, we allocate spacecraft costs to the military and civilian categories according to observed usage. Launch vehicle costs are allocated to the military or civilian category based on the usage of the satellites they launch.

This analysis indicates that the early Soviet space program was civilian oriented and dominated by the very expensive lunar and planetary programs; but, after 1974 and the cancellation of the manned lunar program, space activities became military oriented (see figure 6). During the late 1970s and early 1980s, we estimate that at least two-thirds of the procurement and operating costs and three-fourths of the R&D costs were accounted for by military or military-related missions. Reports by Soviet scientists of cutbacks in funds for civilian scientific missions suggest that the militarization of the space program will continue. We project a resurgence of the civilian lunar and planetary program by the late 1980s or early 1990s, but this resurgence will come after most of the new military spacecraft have been developed

Figure 6
Comparison of Soviet Military Versus Civilian Space Activities, 1965-84

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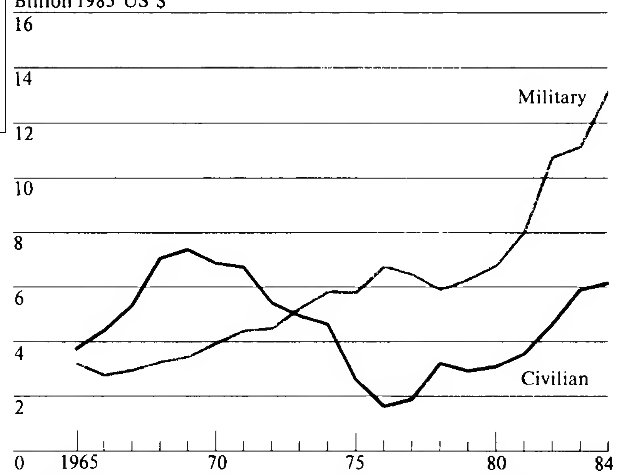
Billion 1983 US $



Soviet space missions are allocated to these categories on the basis of whether the US Defense Department or NASA would fund a similar program in the United States. For dual-use spacecraft we allocate a portion of the cost, based on observed use, to each category. Costs include R&D, procurement, and operating costs for identified programs only.

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and placed into orbit, thereby lessening the competition for funding. A Soviet response to the US Strategic Defense Initiative (SDI) would probably retard and possibly eliminate this anticipated resurgence.

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Prospects

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Current and planned programs indicate the recent rapid growth in Soviet space program costs will be sustained through the late 1980s, as the new SLVs and manned spacecraft proceed through final engineering, testing, and initial procurement. We have not identified all of the systems that will support Soviet space operations through the 1990s, so we cannot predict confidently the direction of space program expenditures beyond the late 1980s. However, we expect growth to decline after the large programs now in development become operational.

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The rate and composition of the growth of space program expenditures through the remainder of the 1980s depend on the success of a number of Soviet systems now in late stages of development. By far the most important of these systems is the SL-W heavy-lift launch vehicle. Prolonged delay in this program would postpone not only SL-W production—the major component of projected SLV procurement costs—but also procurement of the costly shuttle, space station, and other heavy spacecraft that will depend on the SL-W. Were this to occur—and we believe it unlikely—it would result in a reduction in the growth of space system procurement expenditures similar to that which followed the failure of the SL-X-15 in the early 1970s. SLV R&D costs could rise if the Soviets mounted a crash program to remedy the SL-W's problems, but this rise would not offset the major declines in procurement. [redacted]

Other possible developments that could significantly affect future developments are:

- Major problems in the development of satellites designed to provide timely intelligence collection or military operations support. The cost decreases would be offset somewhat by an increase in the launch rate for existing systems, but Soviet operational capability would be severely degraded.

- A reexamination of the manned program's goals and benefits. This could result either in a reduction of the considerable resource commitment in light of current economic difficulties or an increase in resources, necessary to expand the space station's prestige and make it competitive with the proposed US manned space station.

- A Soviet response to the US SDI. In the short term we would expect little increase in either overall costs or in hardware costs because a response would consist mainly of relatively less costly basic research. Some of this research might be conducted aboard the space station, instead of through the use of separate launches, to reduce costs and risk. [redacted]

Assuming the SL-W and other systems will reach operational capability as expected, we have arrayed projected Soviet space program costs over the 1985-89 period by major mission area (see table 2). These estimates testify to the continuing military dominance of the Soviet space program. Although we estimate that civilian space programs will continue to account

Table 2
The Shares of Major Missions in Projected Space Program Costs, 1985-89

Mission	Key New Systems	Estimated Share of Total Cost
Manned		
Continuous manned presence in space, military R&D, and space manufacturing	Space shuttle Spaceplane Space station Space tug	About one-third

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The major new and costly thrust in the Soviet space program is the greatly expanded manned effort. Soviet development efforts and statements suggest that Moscow perceives two benefits, in addition to international prestige, that justify the substantial cost:

- *Multimission flexibility*. Although a single mission could be performed at a lower cost aboard unmanned spacecraft, the multipurpose space stations allow several missions to be performed at once. They also afford the potential to maintain, adjust, and calibrate sensors and equipment and even to redirect experiments. Recent Soviet statements indicate that the cosmonauts perform a key role in the success of numerous military and scientific experiments conducted aboard Salyut.

- *Future economic benefits*. Manned space stations have already been used to define areas of exploration for natural gas. Soviet writings have also predicted major production operations; one article claimed "spaceships" would manufacture products worth $50 billion by the year 2010. 25X1

Our projections suggest that military space program costs will continue to grow more rapidly than the dollar costs of Soviet defense activities as a whole. Civilian programs are also expected to grow at similar rates in the late 1980s. Both the military and civilian space programs benefit in part from the redirection of R&D assets from other areas, as demonstrated by the aviation industry's current participation in the space shuttle and spaceplane programs. Funds from other areas, however, probably will not be sufficient to support the projected growth in space programs, suggesting these programs will claim a major share of the continuing growth in Soviet defense and civilian R&D expenditures. 25X1

Through the end of this decade, responses to US initiatives such as the manned space station and SDI would more likely result in a reallocation of resources within the space program than in significant increases in spending. Reallocations would probably come from the purely scientific and planetary missions, creating an even more military-oriented program. 25X1

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[redacted] A recent cost study estimated that if Soviet evolutionary systems were to be manufactured in the United States they would cost only one-third to two-thirds as much as their US counterparts. [redacted]

Soviet spacecraft are developed by design teams generally unaffected by layoffs and economic fluctuations and with well-established and consistent leadership. This, and the emphasis on deadlines and performance, tends to perpetuate the reuse or adaptation of previous designs in follow-on spacecraft. Designs with no known antecedents are rare, and multiple use of structures, subsystems, and components in spacecraft of the same vintage and in succeeding generations is typical. These practices reduce both design and manufacturing costs and have enabled the Soviets to achieve their space objectives quickly, economically, and with a high degree of reliability—given their technology. [redacted]

[redacted]

The three-man Voskhod satellite, which was basically an enlarged Vostok, provided the technological base for the Soyuz family. The basic Soyuz has an instrument compartment, command and reentry module, and an orbital compartment containing the docking assembly, which was used from 1966 to 1970 to test rendezvous and docking techniques by forming "pseudo space stations" from multiple spacecraft. The structure was modified slightly in 1971 to carry crews to the Salyut space stations. [redacted]

Soyuz was modified for four additional missions:

- The Zond series was initiated in 1967 as a test bed for manned circumlunar flights. Although the program was canceled in 1970 after five unmanned tests, the reentry capsule and experience may be applicable to future manned lunar systems.

- The unmanned and nonrecoverable Progress resupply vehicle also contains three basic compartments. The aft compartment contains instrumentation similar to that of the Soyuz, but has been extended to house additional electronic equipment. The center compartment has been modified for the resupply of propellant to the space station. The interior of the front cargo compartment has been modified to carry life-support systems and supplies.

- The Soyuz-T spacecraft, now the standard crew-ferry vehicle, was developed directly from Soyuz but also uses advanced digital computer technology and an improved propulsion system.

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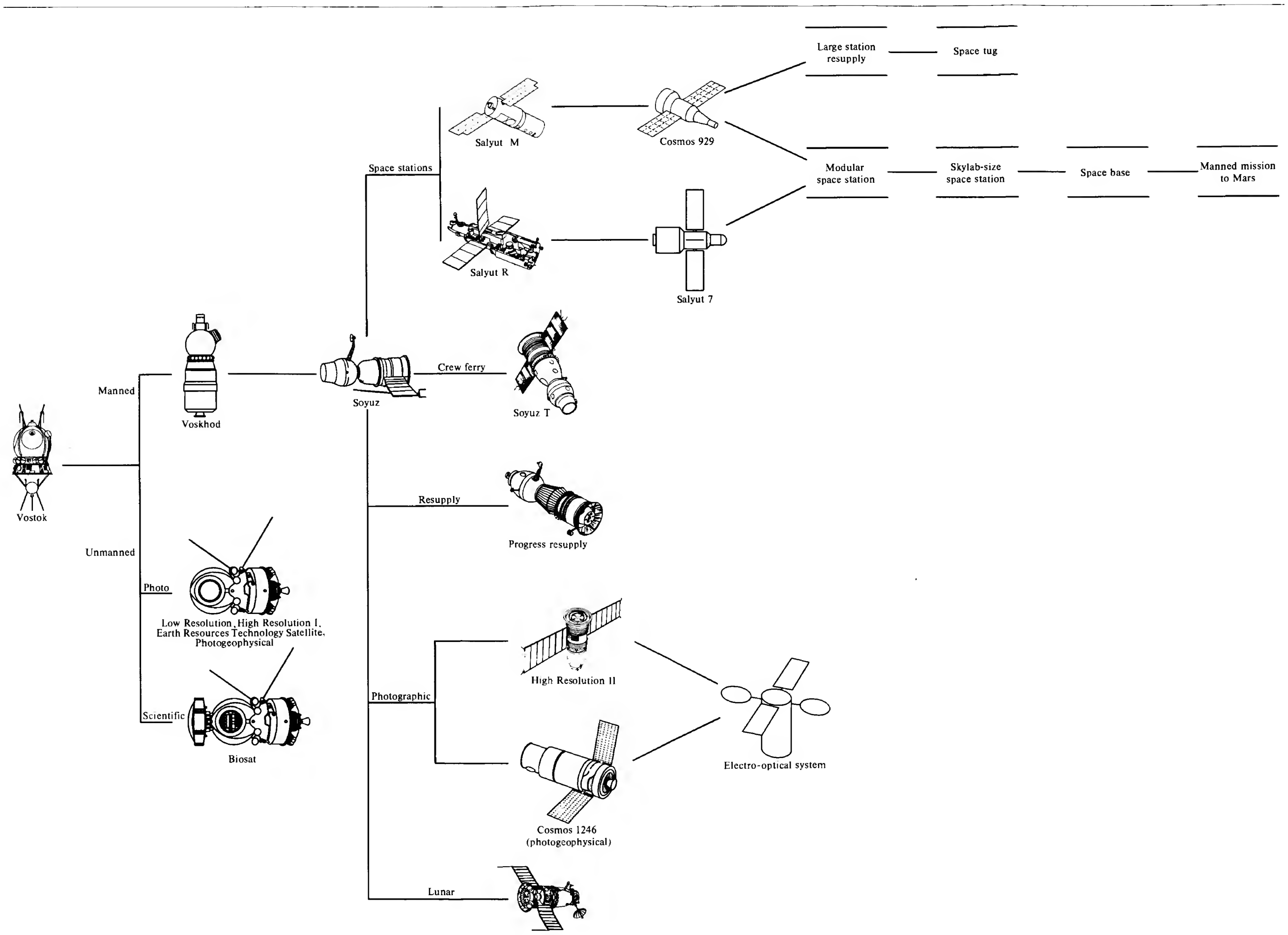
Figure 7
Evolution of the Soviet Space Base



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